

# Forecasting Art Coverage in Vietnam Using the Multilayer Perceptron Neural Network

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**Abstract** - In this research article, the ANN approach was applied to analyze ART coverage in Vietnam. The employed annual data covers the period 2000-2018 and the out-of-sample period ranges over the period 2019-2023. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting ART coverage in Vietnam. The results of the study indicate that ART coverage will be around 68% over the period 2019-2023. We apparently encourage the government to intensify the test and treat approach, create demand for HIV testing services and strengthen TB/HIV collaboration.

**Keywords:** ANN, ART coverage, Forecasting.

## I. INTRODUCTION

Vietnam was the first country in Asia to commit to the global targets of 90-90-90 by 2020 and the goal of ending the HIV epidemic as a public health threat by 2030 (Sabin et al, 2019; Vietnam MOH, 2014). The key drivers of the HIV epidemic in the country are injecting drug users, men who have sex with men, transgender women and female sexworkers (Sabin et al, 2019). By the end of 2016 there 116 000 HIV positive patients on antiretroviral treatment (UNAIDS, 2016). The annual HIV testing coverage among key populations has been noted to be very low and this has been associated with lack of client confidentiality, fear, stigma and discrimination (Vietnam MOH, 2014). Several studies done in Sub-Saharan Africa have shown that community based HIV testing can increase HIV testing coverage (Monisha et al, 2015; Suthar et al, 2013). Many studies done in Cambodia, Malawi and South Africa concluded that task shifting to lay providers is recommended for a range of clinical services including HIV testing services in order to improve HIV testing capacity (Flynn et al, 2017; Kennedy et al, 2017; Jackson et al, 2013; Ledikwe et al, 2013; Mwai et al, 2013; Walensky et al, 2011; Bemelmans et al, 2010; Molesworth et al, 2010; WHO, 2007; Kanal et al, 2005).

The national HIV care and treatment program is mainly funded by PEPFAR (USG, 2019). The aim of the program is to detect and treat HIV cases early so as to reduce morbidity and mortality due to HIV/AIDS. In addition, the country aims to improve voluntary HIV testing, implement harm reduction interventions for high risk populations and utilizing outreach work force to expand community based HIV prevention measures focused on improving HIV knowledge and reducing high risk behaviors among key populations (PEPFAR, 2007; GSO, 2006; WHO, 2005; Khoat et al, 2003). The country adopted the WHO combined HIV prevention strategy which speaks to condom distribution and use, behavior change interventions, Prevention of Mother to Child transmission of HIV (PMTCT), pre and post exposure prophylaxis and promoting Voluntary medical male circumcision. TB and HIV collaboration is key in order to control both TB and HIV since their co-existence increases morbidity and mortality among people living with HIV.

In this paper we aim to model and forecast ART coverage in Vietnam by using the Multilayer Perceptron, ANN (9, 12, 1) model. The neural network framework is composed of 3 layers of neurons with a feed forward network type. The layers are connected by connection weights (Zhao et al, 2020; Nyoni et al, 2020; Yan et al, 2018; Kaushiki & Sahi, 2018; Fojnica et al, 2016; Zhang, 2003). The results of the study are expected to be used in the assessment of progress towards achieving the global targets by 2030 since they reveal the future trends of ART coverage in Vietnam.

## II. LITERATURE REVIEW

Sabin et al (2019) in 2007–2008 conducted a nationwide evaluation of PEPFAR-supported outreach programs in Vietnam. The evaluation focused on assessing program effect on HIV knowledge, high-risk behaviors, and HIV testing among high-risk populations—results relevant to Vietnam’s push to meet global HIV goals. The researchers used a mixed-methods cross-sectional

evaluation design. Data collection encompassed a quantitative survey of 2199 individuals, supplemented by 125 in-depth interviews. Participants were members of high-risk populations who reported recent contact with an outreach worker (intervention group) or no recent contact (comparison group). They assessed differences in HIV knowledge, risky behaviors, and HIV testing between groups, and between high-risk populations. The findings from the study indicated that outreach programs appear to have reduced risky sexual behaviors and increased use of HIV testing services among high-risk populations in Vietnam. These programs could play a key role in reducing gaps in the HIV care cascade, achieving the global 90–90–90 goals, and creating an AIDS-free generation. In another study Tran et al (2019) assessed the stigmatization and discrimination experienced by people living with HIV (PLWH) across multiple social settings such as family, community, and healthcare facilities in Vietnam. A total of 1,016 patients (63.8% males, mean age = 35.4) participated in a cross-sectional study using a culturally tailored HIV stigma measure in three HIV epidemic-concentrated cities in Vietnam. Zero-inflated Poisson models were used to examine factors associated with the number of types of stigma that patients experienced. 86.2% PLWH reported experiencing stigma against HIV/AIDS, more frequently from their community (62.8%) and family (30.2%) than from health care facilities (8%). The level of stigma from community reported by PLWH is associated with socioeconomic status (e.g., income, occupation). The poor and middle economic classes and unemployed patients reported more stigmatization and discrimination from the community. Vu et al (2018) piloted lay provider HIV testing as an innovative approach to reach at-risk populations that never or infrequently HIV test at facility-based services. They conducted a cross-sectional survey and analysis of routine program data in two urban provinces (Hanoi and Ho Chi Minh City) and two rural mountainous provinces (Nghe An and Dien Bien) from October 2015 through September 2017. Acceptability of lay provider testing was defined as the proportion of first-time HIV testers utilizing the service, and effectiveness was measured by HIV positivity and ART initiation rates. Univariate and multivariate analyses were used to determine lay provider testing preference and factors associated with that preference. The study revealed that lay provider HIV testing is an effective approach to reach previously unreached at-risk populations, and, therefore, a critical addition to accelerating Vietnam's attainment of the Joint United Nations Programme on HIV/AIDS 90-90-90 goals. García et al (2012) reviewed and analyzed original studies on HIV prevalence and risk behaviours among men who have sex with men (MSM) in Vietnam. Comprehensive identification of material was conducted by systematic electronic searches of selected databases. Inclusion criteria included studies conducted from 2002 onwards, following a systematic review concluding in 2001 conducted by Colby, Nghia Huu and Doussantousse. Data analysis was undertaken through the application of both the Cochrane Collaboration and ePPI Centre approaches to the synthesis of qualitative and quantitative studies. The research showed that increasing HIV prevalence and the lack of effective protective behaviours such as consistent condom use during anal sex among MSM in Vietnam indicate a potential for a more severe HIV epidemic in the future unless targeted and segmented comprehensive HIV prevention strategies for MSM in Vietnam are designed and programs implemented.

### III. METHOD

The Artificial Neural Network (ANN), which we will apply; is a data processing system consisting of a large number of simple and highly interconnected processing elements resembling a biological neural system. It is capable of learning from an experimental or real data set to describe the nonlinear and interaction effects with great accuracy. ANN-based curve fitting technique is one of the extensively applied artificial intelligence methods that are used for forecasting and prediction purpose. It consists of basically three layers i.e., input layer, hidden layer, and output layer, the present work includes the number of years as input layer and the annual ART coverage in Vietnam as output data for the network. In this research paper, our ANN is based on the hyperbolic tangent function.

#### Data Issues

This study is based on annual ART coverages (referred to as V series in this study) in all age groups in Vietnam. The data covers the period 2000-18 while the out-of-sample forecast covers the period 2019-2023. All the data employed in this research paper was gathered from the World Bank online database.

#### IV. FINDINGS OF THE STUDY

##### DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
22.895	18.000	0.00000	65.000
Std. Dev.	C.V.	Skewness	Ex. kurtosis
22.767	0.99441	0.51335	-1.1227
5% Perc.	95% Perc.	IQ range	Missing obs.
undefined	65.000	41.000	0

##### ANN MODEL SUMMARY FOR ART COVERAGE IN VIETNAM

Table 2: ANN model summary

Variable	V
Observations	10 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	9
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.012875
MSE	0.216158
MAE	0.335764

##### Residual Analysis for the ANN model

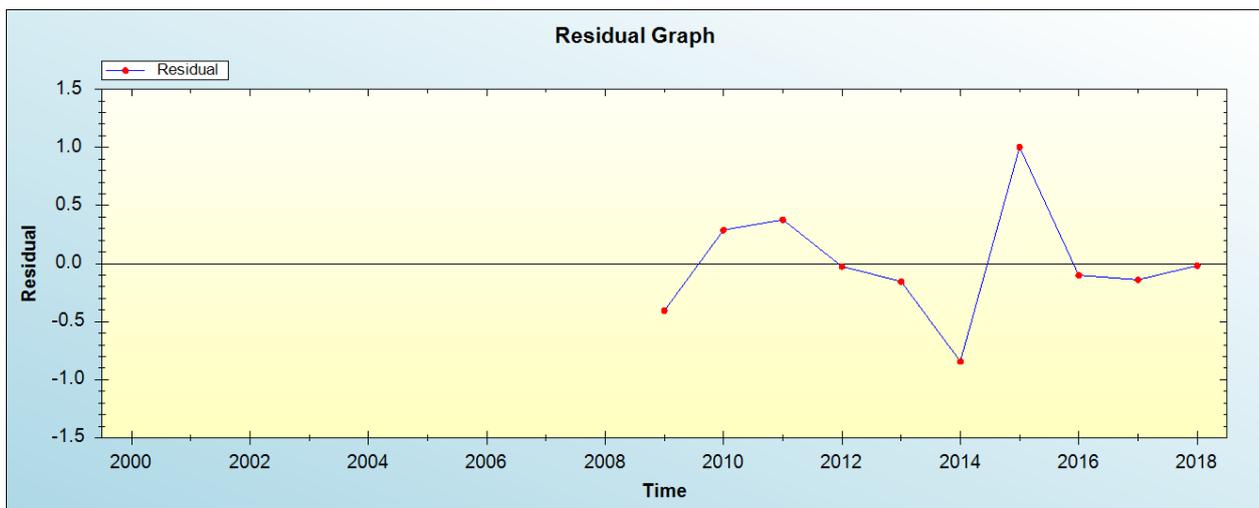
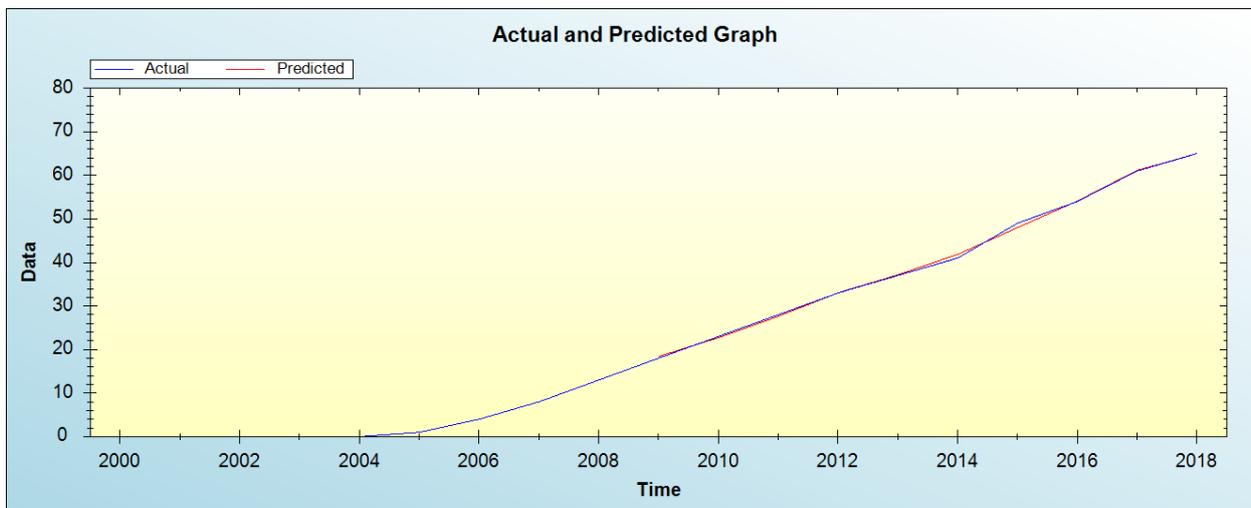


Figure 1: Residual analysis

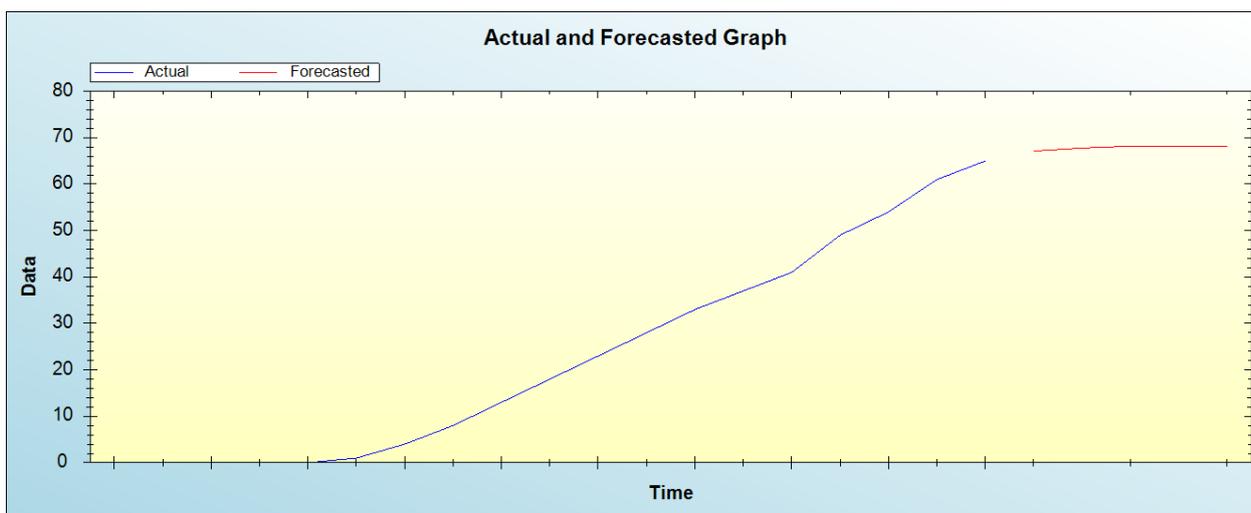
*In-sample Forecast for V*



**Figure 2: In-sample forecast for the V series**

Figure 2 shows the in-sample forecast for V series.

*Out-of-Sample Forecast for V: Actual and Forecasted Graph*



**Figure 3: Out-of-sample forecast for V: actual and forecasted graph**

*Out-of-Sample Forecast for V: Forecasts only*

**Table 3: Tabulated out-of-sample forecasts**

Year	Forecasted ART coverage
2019	67.1413
2020	67.7845
2021	68.1798
2022	68.2030
2023	68.2229

Over the study period, the minimum and maximum ART coverage was 0 and 65 % respectively with an average of 22.9%. ART programmed was rolled out in 2005 hence zero reporting was noted for the period 2000-2004. The data used in this study is positively skewed with an excess kurtosis of -1.1227 meaning that the data is not normally distributed. The residual graph and the model evaluation criteria indicate that the applied model is stable and suitable to forecast ART coverage in Vietnam. The neural

network model simulates the observed data very well. Projections from the model suggest that ART coverage will be around 68% over the period 2019-2023.

## V. CONCLUSION & RECOMMENDATIONS

Over the period 2000-2018, the country recorded an upward trend in ART coverage which indicates that the government is striving to make sure that HIV infected people get access to antiretroviral therapy. The model predicted that ART coverage will likely be around 68 % over the out of sample period. We encourage the authorities to intensify the test and treat approach, creates more demand for HIV testing services and strengthen TB/HIV collaboration.

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